CLAIMS

What is claimed is:

1. A method for measuring the degree to which a printed image on a first side of a sheet is visible when illuminating and viewing a second side of the sheet, the method comprising:

a) creating a calibration image of a reference object containing no image by illuminating the reference object at an initial illumination level;

b) determining an average gray level of the reference object and adjusting the illumination level to achieve a predetermined average gray level;

c) illuminating the sheet at an illumination level the same as that used to create the calibration image and creating an image of the sheet;

d) measuring the ratio of the pixel intensities of the image of the sheet with the corresponding pixel intensities of the calibration image; and

e) calculating a mean value of the ratios of the pixel intensities.

2. An image analysis method for characterizing the showthrough of a printed image on the reverse surface of a substantially planar sample object having a reflective front surface, by measuring the optical reflectance of the front surface with a lens and a photodetector array, the method comprising:

(a) creating a frame-averaged dark current image representing the response of the photodetector array in the absence of light;

(b) uniformly illuminating, with a diffuse light source, the front surface of a reference object, said reference object having no image on its reverse, and creating a calibration image of the reference object, comprising the steps of ;

(1) illuminating the front surface of the reference object with the diffuse light source, the output of the light source being set to an initial illumination output level;

(2) creating a frame-averaged image of the front surface of the reference object;

(3) determining the average gray level in the image of the reference object created in step(b)(2);

(4) adjusting the illumination level by adjusting the output of the light source and repeating steps (2) and (3) until the average light level reflected by the front surface of the reference object causes an average gray level in the image of step (2) to be within a

predetermined range of a predetermined value within the dynamic range of the analog to digital converter, thereby establishing a predetermined illumination level;

(5) creating a frame-averaged reference image of the front surface of the reference object;

(6) creating a dark-current corrected calibration image of the reference object by subtracting the frame-averaged dark current image of step (a) from the frame-averaged reference image of step (5) on a pixel by pixel basis and storing the resulting image in the memory;

(c) uniformly illuminating, with the diffuse light source at the predetermined illumination level, the front surface of a sample object having a printed image on the reverse surface;

(d) creating a frame-averaged image of the front surface of the sample object;

(e) creating a dark-current-corrected image of the front surface of the sample object by subtracting the frame-averaged dark current image of step (a) from the frame-averaged image of step (d) on a pixel by pixel basis and storing the resulting image in the memory; and

(f) analyzing the dark-current-corrected frame-averaged image by calculating the ratio of the image of step (e) with the image of step (b) (6) on a pixel by pixel basis to quantify showthrough.

3. The method of Claim 2, wherein the step (b) (2) of creating a frame-averaged image of the front surface of the reference object and step (d) of creating the frame-averaged image of the surface of the sample object each comprise the steps of:

(1) imaging the light reflected from the front surface onto a photodetector array to create an electrical signal representative of the image;

(2) digitizing the electrical signal using an analog to digital converter;

(3) frame averaging the electrical signal a predetermined number of times; and

(4) storing the frame-averaged digitized representation of the image as an array of picture elements in a memory.

4. The method of Claim 2, wherein the analyzing step (f) comprises the steps of:

(1) calculating a ratio of the image of step (c) with the image of step (b) (6) on a pixel by pixel basis;

(2) calculating a mean value of the ratios of the pixels; and

(3) subtracting the mean value from the value 1.0 to create a quantitative representation of showthrough.

5. The method of Claim 2, further comprising an optical filter in combination with the lens and the photodetector array, so that the overall spectral response of the combination is such that the image analysis method utilizes information in a predetermined spectral region.

6. The method of Claim 5, further comprising the optical filter being positioned between the lens and the photodetector array, so that the overall spectral response of the combination is such that the image analysis method utilizes information in a spectral region that approximates the photopic response of the human eye.

7. The method of Claim 2, wherein the illumination adjusting step (b) (4) is performed using a binary search method within a predetermined range of light levels.

8. The method of Claim 2, wherein the illumination adjusting step (b) (4) is performed using a binary search method within the full range of light levels.

9. The method of Claim 2, wherein a region of interest (ROI) in a field of view is selected before performing step (b) through (f).

10. The method of Claim 2, wherein the reference object is comprised of a plurality of objects, each having no image on its reverse surface, stacked atop one another, such that a change in the number of objects in the stack results in no measurable difference in average gray level in the image of the reference object.

11. The method of Claim 10, wherein the reference object is comprised of a plurality of sheets of paper.

12. The method of Claim 2, wherein the sample object is a sheet of paper.

13. An apparatus for measuring the degree to which a printed image on a first side of a substantially planar sample object is visible when

illuminating and viewing a second side of the substantially planar sample object, the apparatus comprising:

a) a light tight enclosure comprising a sample object holder, an illuminating assembly for diffusely illuminating the sample object, and an imaging assembly,

b) a computerized image processing assembly for controlling the illumination level of the sample object created by the illuminating assembly and for receiving images created by the imaging assembly and analyzing those images, wherein

(1) the sample object holder comprises a support frame and a support platen for holding the sample object to be measured in a predetermined plane,

(2) the illuminating assembly comprises:

(i) a hemispherical reflector positioned adjacent the sample holder so that the predetermined sample plane corresponds to the equatorial plane of the hemisphere, the hemisphere having a diffusely reflecting interior surface and a polar opening for mounting the imaging assembly,

(ii) a circular array of light sources positioned above the equatorial plane and arranged to illuminate the diffusely reflecting interior surface of the hemisphere;

(iii) a photodetector positioned adjacent the array of light sources and oriented to sense the level of light diffusely reflected from the interior surface of the hemisphere;

(3) the imaging assembly comprising:

(i) a lens,

(ii) a photodetector array, the lens focussing an image of the object onto the photodetector array, each photodetector in the array creating an electrical signal representative of the light reflected from the front surface of the object, the photodetector array being connected to the computerized image processing assembly.

14. The apparatus of Claim 13, wherein each light source comprises a white light emitting diode.

15. The apparatus of Claim 13, further comprising an optical filter in combination with the lens and the photodetector array, the filter having a

spectral response such that the overall spectral response of the apparatus is a predetermined spectral response.

16. The apparatus of Claim 15, further comprising an optical filter being positioned between the lens and the photodetector array, so that the overall spectral response of the apparatus approximates the photopic response of the human eye.

17. The apparatus of Claim 13, wherein the interior surface of the hemisphere has a substantially non-reflecting region adjacent the polar opening so that specular reflections from the object are not imaged by the imaging assembly.

18. The apparatus of Claim 13, wherein the interior surface of the hemisphere has a substantially non-reflecting region adjacent the polar opening corresponding to the area of the sample object being imaged.